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REVIEW AND SYNTHESIS INTERNATIONAL VEGETATION CLASSIFICATION

Braun-Blanquet meets EcoVeg: a formation and division level classification of European phytosociological units

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Abstract

Aims: To link the Braun-Blanquet units of the EuroVegChecklist (EVC) with the upper levels of the International Vegetation Classification (IVC), and to propose a division level classification for Europe. **Study area:** Europe. **Methods:** We established a tabular linkage between EVC classes and IVC formations and identified mismatches between these two levels. We then proposed IVC division level units to organize EVC classes. **Results:** We organized the EVC classes into 21 formations and 30 divisions. We flagged classes that did not fit comfortably within an existing formation, either because its content corresponded to more than one formation or because it did not fit any formation description. In a few cases, we split EVC classes because they seemed too heterogenous to be assigned to a single formation. **Conclusions:** The IVC approach adds a set of physiognomic and ecological criteria that effectively organizes the EVC classes, which are already being increasingly informed by physiognomy. Therefore, the formation concepts are relatively natural extensions of concepts already embedded in the classes. However, physiognomic placement of Braun-Blanquet classes can be difficult when the sampling of the vegetation is at finer grain than usual in the respective formation (tall-scrub, annual pioneer communities). Some EVC classes seem too heterogenous to fit into the IVC formation system. Delimitation of these classes has often been a matter of debate for many decades, and the IVC perspective might help to solve these intricate issues. In other cases, mismatches between phytosociological classes and IVC formations might better be solved by emending the current formation concepts.

Abbreviations: BB = Braun-Blanquet; EVC = EuroVegChecklist; IVC = International Vegetation Classification.

Keywords

Braun-Blanquet approach, class, division, EcoVeg approach, Europe, EuroVegChecklist, formation, International Vegetation Classification, macrogroup

Introduction

There is an increasingly wide array of tools that permit ecologists to describe, classify, and map the diversity of ecosystems around the globe, including large scale plot datasets and remotely sensing imagery. These tools have led to a renewed interest in global hierarchical typologies of vegetation types ("bioecosystems"). Such typologies provide a knowledge structure for interpreting ecosystem diversity, and guiding resource management, conservation assessments, and species-habitat relationships. A commonly used set of criteria used to organize these hierarchies are physiognomy and structure, ecological functions and factors, floristics, and biogeography (Faber-Langendoen et

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al. 2014, 2020; Moncrief et al. 2016; Guo et al. 2018; Mucina 2018; Keith et al. 2020); less commonly, zonal criteria are introduced based on vegetation-climatic relationships (Luebert and Pliscoff 2006; Mucina et al. 2016; MacKenzie and Meidinger 2018). These global classification efforts are strongest when building on existing, data driven, extensive, plot-based / inventory-based classifications at regional to continental scales.

A recent European synthesis at the continental scale – the "EuroVegChecklist" (EVC) – brought together a comprehensive hierarchical system of alliances, orders, and classes of Braun-Blanquet (BB) syntaxonomy, briefly characterizing each unit in ecological and geographic terms, and providing a list of diagnostic species for all classes (Mucina et al. 2016). However, the Braun-Blanquet approach, by relying on floristic composition and similarity for its hierarchy, lacks a coherent global framework. This is because, at upper levels, vegetation types are largely equally distinct in their floristic differences – i.e., they have no or very few species in common, and there is no clear basis to organize the classes within the system. Various proposals have been made over the years on how to organize BB classes using external criteria, beginning with the "sociological progression" and the "circle of vegetation" (Braun-Blanquet 1921, 1964), to a new division level above class (Jakucs 1967), to formation concepts (Passarge 1966; Theurillat et al. 1995; Rodwell et al. 2002) and, most recently, zonal concepts (Mucina et al. 2016). Fundamentally, the system is open to any of these external approaches.

The International Vegetation Classification (IVC) maintained by NatureServe and partners, which uses the EcoVeg approach (Faber-Langendoen et al. 2014, 2018, 2020), has developed a global set of formations (Faber-Langendoen et al. 2016) and an increasingly comprehensive set of division level units (e.g., Sayre et al. 2013; Dixon et al. 2014; Muldavin et al. 2021). The formation is physiognomic-structural in character with supplementary ecological information and defined by dominance of a given growth form in the uppermost stratum of the community, or by a combination of dominant growth forms (Whittaker 1975). These formations have also been widely used to define biomes (Moncrieff et al. 2016; Faber-Langendoen et al. 2020). The term "division" was adopted from the Braun-Blanquet approach, and it was originally proposed as a level above the class (Jakucs 1967; Westhoff and van der Maarel 1973). It unites related phytosociological classes (or, in the EcoVeg hierarchy, macrogroups) within a biogeographic region on the basis of common division-level character species, growth forms, and ecology. The division concept introduces floristic criteria, by which the upper-level formation types can be subdivided by continental scale biogeographic species pools. In turn, from the bottom-up, shared growth forms among division types, which reflect a set of shared climatic and edaphic factors, lead to their placement within the same formation.

The Braun-Blanquet approach places a strong emphasis on plant species composition. Specifically, the approach deals with plant species co-occurrences, or, in other words, species compositional patterns and gradients at the scale of the plant community. It works with empirical, plot-based data and techniques to compare floristic composition among communities and relates these patterns to environmental factors (Westhoff and Van der Maarel 1973; Ewald 2003; Dengler et al. 2008). It organizes vegetation types in a hierarchical system based on floristic composition and similarity.

The EcoVeg approach places a strong emphasis on both plant species composition and growth form, interpreting the role of both through the lens of biogeographic and ecologic factors. Specifically, the EcoVeg approach works with the same plot-based data and techniques of the Braun-Blanquet approach but expands the analyses to include local to global gradients of both composition and growth form. In turn, it organizes vegetation types in a hierarchical system based on the patterns and relationships of vegetation to ecological and biogeographic gradients. Thus, e.g., plant communities occurring in Mediterranean climates around the globe have convergent adaptations in structure, life forms and flora evolution (Dallman 1998; Pignatti et al. 2002), which provide the basis for placing these vegetation units together in the "Mediterranean Scrub & Grassland" formation of the IVC, despite sharing no species in common.

Despite the primary focus of the Braun-Blanquet approach on floristic composition and similarity, its fundamental goals align with that of the EcoVeg approach: to describe the patterns of plant communities that form a matrix of global, regional and local vegetation cover, and to investigate and explain the ecological context of these communities (Mueller-Dombois and Ellenberg 1974; Faber-Langendoen et al. 2014; Guarino et al. 2018). However, to be successful, some consistency is needed in extending the floristic criteria to allow for recognition of continental and global patterns of vegetation. The Braun-Blanquet approach still lacks an agreed upon set of constraining attributes at the class level (Pignatti et al. 1995; Mucina et al. 2016). These could well include physiognomic or growth form criteria, which are largely determined by the dominant species, as well as biogeographic criteria, which integrate the full suite of species.

Although the primary attributes of the EcoVeg approach include plant species composition and growth form, and their interpretation in light of biogeographic and ecologic factors, there is as of yet, little systematic documentation of these attributes. The IVC is largely heuristic, relying on practical judgement as to the most probable organizing factors that guide the definition and placement of vegetation types. It thereby achieves a reasonable framework for addressing the urgency of conservation and resource management issues, while being open to rigorous long-term improvement. That said, these judgements are often firmly grounded in the integration of existing information on a wide range of local, regional, continental, and global vegetation types. Thus, the units form effective hypotheses open to further testing.

The IVC formations (Faber-Langendoen et al. 2016) provide suitable concepts that can be used to assess their strengths and limits for organizing BB classes, which have well described diagnostic concepts (Mucina et al. 2016). By contrast, the equivalent unit in the EcoVeg approach to the BB class is the macrogroup, which rarely contains a definitive list of diagnostic species, relying instead on expert-based descriptions of regional dominant, constant, and diagnostic species, along with growth form, structure, and ecology (Faber-Langendoen et al. 2014). Thus, the two approaches are now well positioned to benefit from a mutual collaboration focused on the class level of the Braun-Blanquet approach and the division and formation levels of the EcoVeg approach. In addition, whereas the phytosociological classes described between 1926 and 1950 were often quite heterogeneous in terms of physiognomy and dominant growth forms, the Braun-Blanquet system has been evolving towards a synthesis between a purely floristic and a formation system during the last 50 years (Guarino et al. 2018). We seek here to demonstrate the merits of this trend.

More specifically, we link the BB units of the EuroVegChecklist 1 (EVC1; vegetation dominated by vascular plants) with the upper levels of the International Vegetation Classification (IVC), asking the following questions:

(1) Which classes do or do not fit comfortably within an existing formation?
(2) Are there any classes which are too heterogeneous in terms of ecology or physiognomy and therefore should be split?
(3) Are there formations which are too broad (i.e., include classes that should be separated) or, on contrary, too narrow (i.e., separate classes that should be placed together), or which should be amended in another way?

Finally, we propose a division level classification for Europe.

Methods

The concept of Formation and Division in the IVC

We here provide the definitions of the EcoVeg formation and division levels relevant to this study (from Faber-Langendoen et al. 2014; links to descriptions of formations applicable to Europe are provided in Appendix 1).

- Formation Class (L1): broad combinations of dominant general growth forms adapted to basic moisture, temperature, and/or substrate or aquatic conditions.
- Formation Subclass (L2): combinations of general dominant and diagnostic growth forms that reflect global macroclimatic factors driven primarily by latitude and continental position, or that reflect overriding substrate or aquatic conditions.
- Formation (L3): combinations of dominant and diagnostic growth forms that reflect global macroclimatic conditions as modified by altitude, seasonality of precipitation, substrates, and hydrologic conditions (cf. "formation-type" and "biome-type" of Whittaker 1975).
- Division (L4): combinations of dominant and diagnostic growth forms and a broad set of diagnostic plant species that reflect biogeographic differences in composition and continental differences in mesoclimate, geology, substrates, hydrology, and disturbance regimes. Whereas the formation level (L3) is more strictly physiognomic, the division level includes both physiognomic and floristic criteria. (cf. "biome" of Whittaker 1975, "continental biome" of Faber-Langendoen et al. 2020).

Assessment of placement of EVC classes within IVC formations

We established a tabular linkage between EVC classes and IVC formations and identified mismatches between these two levels. We assessed the relative acceptability of each EVC class within a formation based on four criteria: (i) growth form, (ii) biogeography (including macroclimate), (iii) ecology (edaphic site conditions and disturbance, both natural and anthropogenic), (iv) floristics (i.e., the floristic coherence of the class, with special emphasis on the dominant layer). We placed classes within a formation whenever class concepts largely contained the attributes of a formation, while noting various difficulties with the boundaries of concepts. We assessed class fit within the formation using three categories: good (G), fair (F) and poor (P), and we flagged any classes that did not fit comfortably within an existing formation, either because its content corresponded to more than one formation or because it did not fit any formation description. In cases of poor fit, we checked whether splitting the EVC class would lead to an increase in the fit.

To assess class characteristics, we mainly relied on the description of the classes in Mucina et al. (2016), which contain descriptors for accepted syntaxa, including (1) the physiognomy of the vegetation classified within the given unit (e.g. forest, grassland, ericaceous scrub, aquatic vegetation, etc.), sometimes with indication of dominant plant species or growth form (e.g. grass-dominated); (2) their unifying ecological context (e.g. mesic, nutrient-poor soils, coastal cliffs under sea-spray influence); and (3) their distribution. Classes of pioneer and seral communities that often occur as small patches within a matrix of vegetation belonging to another class (e.g., patches of tall scrub within a grassland matrix, fringe vegetation on forest edges; Chytrý and Otýpková 2003) were placed into the formation corresponding to large (≥ 100 m^2) patches of these classes, even though such large patches might be relatively rare. Classes occurring under both semi-natural and strongly anthropogenic site conditions were placed in

formations of semi-natural vegetation, while classes exclusively found on anthropogenic sites were placed in the formation class "Agricultural & Developed Vegetation" (Faber-Langendoen et al. 2016).

Finally, we evaluated the homogeneity of formations with respect to the attributes of the included classes.

Recognition of IVC divisions for European vegetation

We reviewed prior division concepts developed for European forests (Faber-Langendoen et al. 2020) and grasslands (Dixon et al. 2014). The grassland divisions were developed globally, providing some guidance on scaling the concepts for Europe. We developed divisions that organize the EVC classes and represent distinct physiognomic, biogeographic, climatic, and edaphic types within a formation. For the naming of divisions, we follow the biogeographic terminology of the European Environment Agency where appropriate (Cervellini et al. 2020).

Results

Here we summarize the placement of all European classes into IVC formations and our proposed divisions for organizing all BB classes. We briefly explain issues of moderate to poor fit between formations and classes. Possible solutions are addressed in the Discussion. The detailed assessment of class fit (based on growth form, biogeography, ecology, and floristics) within formations is provided in Suppl. material 1.

The formation names strictly follow Faber-Langendoen et al. (2016). In cases where these names do not fully reflect the content of the included BB units, we additionally provide a short diagnosis below the formation name. An overview including all hierarchical levels is provided in Appendix 1.

1.B.1. Warm Temperate Forest & Woodland

[Mediterranean and warm temperate forest, woodland and tall scrub]

Macaronesian Warm Temperate Forest & Tall Scrub

- OLE: *Oleo cerasiformis-Rhamnetea crenulatae* p.p. [excl. OLE-02 *Cisto canariensis-Micromerietalia hyssopifoliae*]
  Remark: While the core of this class are tall shrub and woodland communities, the order OLE-02 *Cisto canariensis-Micromerietalia hyssopifoliae* includes low scrub, which rather corresponds to formation 2.B.1. Mediterranean Scrub & Grassland.
- LAU: *Pruno lusitanicae-Lauretea azoricae*
- AZO: *Lauro azoricae-Junipiretea brevifoliae*
  Remark: This class contains both evergreen laurophyll forest and heath seral to forest. Some adjustments in the circumscription of the class might be necessary to fit it into this formation.
- CAN: *Cytiso-Pinetea canariensis*

Mediterranean Basin Warm Temperate Sclerophyllous Forest & Tall Scrub

- QUI: *Quercetea ilicis*
- CYT: *Cytisetea scopario-striati*
  Remark: This class contains broomy shrub communities seral to forest and woodland. *Cytisus scoparius* is up to 3 m high, the same as *Prunus spinosa*, *Rosa canina* and other *Crataego-Prunetea* species. Therefore, we preliminarily consider this class as a tall scrub. The order CYT-03 *Spartio juncei-Cytisetalia scoparii* is not Mediterranean, but an oceanic warm-temperate unit.

1.B.2. Cool Temperate Forest & Woodland

[Cool temperate forest, woodland and tall scrub]

Western Eurasian Cool Temperate Forest & Tall Scrub

Here we propose to organize the classes by three division groupings, zonal, seral, and dry pine forests. These groupings account for the major gradients within this division that historically dominated much of the temperate European landscape. The one challenge may be that the seral grouping contains shrub/small tree physiognomy that straddles the shrub and tree formations. Floristically, ecologically, and biogeographically, those classes mostly belong together with the zonal temperate forest class grouping. However, low scrub cannot be accommodated in this formation and should be excluded (see Remarks under individual classes below).

Western Eurasian Cool Temperate Forest & Tall Scrub 1 (zonal)

- FAG: *Carpino-Fagetea sylvaticae*
- PUB: *Quercetea pubescentis*
- QUE: *Quercetea robori-petraeae*

Western Eurasian cool Temperate Forest & Tall Scrub 2 (seral scrub)

- RHA: *Crataego-Prunetea* p.p.max.
  Remark: The low scrub of the steppe zone (RHA-01J *Prunion fruticosae*) better fits in formation 2.B.2. Temperate Grassland & Shrubland.
- ARE: *Salicetea arenariae* p.p.min.
  Remark: This class mostly includes low scrub, which corresponds to formation 2.B.4. Temperate to Polar Scrub & Herb Coastal Vegetation.
- LON: *Lonicero-Rubetea plicati*
- ROB: *Robinietea*

Western Eurasian Cool Temperate Forest & Tall Scrub 3 (azonal dry pine forests)

- ERI: *Erico-Pinetea*

- PYR: *Pyrolo-Pinetea sylvestris*
- SAB: *Junipero-Pinetea sylvestris*

Southern Siberian Cool Temperate Forest

The Southern Siberian Cool Temperate Forest division is the classic example of "hemiboreal" vegetation. Hemiboreal refers to the northernmost subzone of the temperate zone, so when paralleling the latitudinal zones with the elevational belts of temperate mountains, hemiboreal would be middle montane, and boreal would be high montane to subalpine. Temperate high montane to subalpine forests are here proposed to be included within 1.B.4. Boreal Forest & Woodland. The hemiboreal forests of Eastern Europe are not well studied from a BB perspective, and it is unclear which class they belong to. They are transitional between the *Carpino-Fagetea* and *Vaccinio-Piceetea*.

- ASA: *Asaro europaei-Abietetea sibiricae*
- BRA: *Brachypodio pinnati-Betuletea pendulae*

1.B.3. Temperate Flooded & Swamp Forest

[Mediterranean, temperate and boreal forest, woodland, and tall scrub on base-rich, flooded or permanently wet soils]

Western Eurasian Rich Flooded & Swamp Forest & Tall Scrub

The classes below fit fairly well within this formation but are not restricted to the temperate zone.

- POP: *Alno glutinosae-Populetea albae*
- PUR: *Salicetea purpureae*
- ALN: *Alnetea glutinosae*
- FRA: *Franguletea*

Eurasian Arid Flooded Forest & Tall Scrub

The classes included here vary from scrub to small tree.

- NER: *Nerio-Tamaricetea*
- TAM: *Tamaricetea arceuthoidis*

1.B.4. Boreal Forest & Woodland

[Temperate high montane to subalpine and boreal forest, woodland, and tall scrub]

Eurasian Boreal & Temperate High Montane Forest & Tall Scrub

This division accommodates the vast areas of boreal forest across Eurasia. We here propose to include both the boreal forest proper, as well as temperate high montane to subalpine spruce-fir-pine vegetation. Strictly speaking the current formation concept treats the latter as part of the Cool Temperate Forest & Woodland formation (I.B.2).

- PIC: *Vaccinio-Piceetea* p.p.max. [excl. *Vaccinio uliginosi-Pinetea*]

  Remark: This class, while having its main distribution in the boreal zone, also includes montane and subalpine forests of the temperate zone. The orders of oligotrophic wooded mires (PIC-07 *Vaccinio uliginosi-Pinetalia sylvestris* and PIC-08 *Calamagrostio purpureae-Piceetalia obovatae*) are excluded (see Formation 1.B.5.).
- MUG: *Roso pendulinae-Pinetea mugo*
  Remark: Despite being restricted to the subalpine belt of temperate mountains, this unit ecologically corresponds to boreal forest and scrub. The *Roso pendulinae-Pinetea mugo* is a controversial class concept. Traditionally, it was treated as part of the *Vaccinio-Piceetea*.
  Placement of this class is more acceptable if the formation concept is revised to be "Boreal & Temperate High Montane Forest & Woodland" (cf. Keith et al. 2020).
- VIR: *Betulo carpaticae-Alnetea viridis*
  Remark: This class includes both boreal and temperate subalpine communities.

1.B.5. Boreal Flooded & Swamp Forest

[Boreal and temperate forest, woodland, and tall scrub on wet, acidic soils]

Eurasian Boreal Acidic Flooded & Swamp Forest & Tall Scrub

- PIC: *Vaccinio-Piceetea* p.p.min. [*Vaccinio uliginosi-Pinetea*]
  Remark: Here we preliminarily accept the class *Vaccinio uliginosi-Pinetea*, comprising oligotrophic wooded mires included in the *Vaccinio-Piceetea* by Mucina et al. (2016) (PIC-07 *Vaccinio uliginosi-Pinetalia sylvestris* and PIC-08 *Calamagrostio purpureae-Piceetalia obovatae*). Boreal flooded forest and tall scrub on rich soils belong to the classes *Alno glutinosae-Populetea albae* and *Salicetea purpureae*, which are accommodated in the temperate flooded and swamp Formation 1.B.3. The order *Vaccinio uliginosi-Pinetalia sylvestris* also includes oligotrophic wooded mires of eastern Central Europe.

2.B.1. Mediterranean Scrub & Grassland

[Mediterranean low scrub and grassland]

Mediterranean Basin Scrub & Grassland

- ROS: *Ononido-Rosmarinetea*
- LAV: *Cisto-Lavanduletea stoechadis*
- LYG: *Lygeo sparti-Stipetea tenacissimae*
- SAC: *Stipo giganteae-Agrostietea castellanae*
- BUL: *Poetea bulbosae*

- TUB: *Helianthemetea guttati*
  Remark: This class includes annual vegetation, often forming small patches within larger perennial scrub and grassland.
- TRA: *Stipo-Trachynietea distachyae*
  Remark: This class includes annual vegetation, often forming small patches within larger perennial scrub and grassland.

Macaronesian Scrub & Grassland

- OLE: *Oleo cerasiformis-Rhamnetea crenulatae* p.p. [OLE-02 *Cisto canariensis-Micromerietalia hyssopifoliae*]

2.B.2. Temperate Grassland & Shrubland

[Temperate and southern boreal low scrub, heath, and grassland vegetation]

Azorean Warm Temperate Grassland & Heath

- TOL: *Tolpido azoricae-Holcetea rigidi*
  Remark: Endemic class of the Azores. Its floristic-biogeographic relationship to other grassland classes remains to be evaluated.

European Temperate Grassland & Heath

These are a diverse group of classes, including both lowland and montane grasslands and heath. In contrast to the situation in eastern North America, where there is a clear demarcation between native and planted grasslands, traditional European pastures and hay meadows of the *Molinio-Arrhenatheretea* are semi-natural communities and therefore included here rather than under 7.B.2 Pasture & Hay Field Crop. However, they are grouped with other ruderal classes to reflect their intermediate position between more strictly cultural grasslands and native grasslands.

European Temperate Grassland & Heath 1 (natural & semi-natural)

- RHA: *Crataego-Prunetea* p.p.min. [*Amygdaletea nanae*]
  Remark: The low scrub of the steppe zone (RHA-01J *Prunion fruticosae*) is placed under this formation while we include tall scrub in formation 1.B.2. Cool Temperate Forest & Woodland (see above).
- ULI: *Calluno-Ulicetea*
- NAR: *Nardetea strictae*
- FES: *Festuco-Brometea*
- GER: *Trifolio-Geranietea sanguinei*
- ONO: *Festuco hystricis-Ononidetea striatae*
  Remark: Submediterranean dry calcicolous grasslands, similar to the rocky grasslands of the *Festuco-Brometea*. Delimitation against alpine grasslands of the class *Elyno-Seslerietea* needs further revision.
- COR: *Koelerio-Corynephoretea canescentis*
- SED: *Sedo-Scleranthetea*
  Remark: This class includes pioneer vegetation dominated by annuals and succulents, often forming small patches within larger perennial scrub and grassland.

European Temperate Grassland & Heath 2 (ruderal & strongly anthropogenic)

- MOL: *Molinio-Arrhenatheretea*
  Remark: This class is a poor fit to this formation because it contains both more natural and strongly anthropogenic grasslands, some of which may fit into cultural grassland formation Pasture & Hay Field Crop (7.B.2). Moreover, it contains both upland grasslands and wet meadows, the latter which may better fit the concept of Temperate to Polar Freshwater Marsh, Wet Meadow & Shrubland (2.C.4).
- ART: *Artemisietea vulgaris*
  Remark: Perennial forb vegetation, mostly of ruderal and strongly anthropogenic habitats.
- EPI: *Epilobietea angustifolii*
  Remark: Perennial forb vegetation of ruderal or seral habitats, including tall-herb vegetation along rivers.

2.B.3. Boreal Grassland & Shrubland

[Temperate high montane to subalpine and boreal low scrub, grassland, and forb vegetation]

European Boreal & Temperate High Montane Scrub & Herb Vegetation

This formation needs further review in Europe. We here propose to include both the boreal grasslands and shrublands proper, as well as boreo-temperate high montane to subalpine grassland and shrubland vegetation. Strictly speaking, the current formation treats the latter within the Temperate Grassland & Shrubland formation (2.B.2.). As further explained below, these three open classes correspond to the forest classes in the boreal forest and scrub formation 1.B.4.

- LOI: *Loiseleurio procumbentis-Vaccinietea* p.p. [excl. LOI-03A *Loiseleurio-Arctostaphylion*]
  Remark: This class is quite heterogenous. It mostly corresponds to the *Vaccinio-Piceetea*, to which it is floristically closely related. However, the arctic and boreo-alpine tundra scrub of LOI-03A cannot be accommodated here; rather, it is included in formation 4.B.2.
- RHO: *Rhododendro hirsuti-Ericetea carneae*
  Remark: This class corresponds to the *Roso pendulinae-Pinetea mugo*, to which it is floristically closely related. Despite being restricted to the subalpine belt of temperate mountains, this unit ecologically corresponds to boreal scrub and herb vegetation.
- MUL: *Mulgedio-Aconitetea*
  Remark: This class corresponds to the *Betulo-Alnetea viridis*, to which it is floristically closely related.

2.B.4. Temperate to Polar Scrub & Herb Coastal Vegetation

[Mediterranean, temperate, boreal, and arctic low scrub, grassland and forb vegetation of coastal cliffs and dunes]

Euro-Atlantic Coastal Scrub & Herb Vegetation

- ARE: *Salicetea arenariae* p.p.max.
  Remark: Tall scrub on older dunes is placed in 1.B.2. Cool Temperate Forest & Woodland.
- AMM: *Ammophiletea*
- CRU: *Helichryso-Crucianelletea maritimae*
- CRI: *Crithmo-Staticetea*
- CAK: *Cakiletea maritimae*

Macaronesian Coastal Scrub & Herb Vegetation

- MOQ: *Polycarpaeo niveae-Traganetea moquini*
- JUN: *Juncetea maritimi*
- SAL: *Salicornietea fruticosae*
- SPA: *Spartinetea maritimae*
- THE: *Therosalicornietea*
- SAG: *Saginetea maritimae*

2.C.2. Temperate to Polar Bog & Fen

Eurasian Bog & Fen

- OXY: *Oxycocco-Sphagnetea*
- SCH: *Scheuchzerio palustris-Caricetea fuscae*

2.C.4. Temperate to Polar Freshwater Marsh, Wet Meadow & Shrubland

[Mediterranean, temperate, boreal and arctic freshwater springs and marshes]

Eurasian Freshwater Marsh, Wet Meadow & Shrubland

For wet meadows see remark under MOL *Molinio-Arrhenatheretea* above.

- PHR: *Phragmito-Magnocaricetea*
- MON: *Montio-Cardaminetea*
- LIT: *Littorelletea uniflorae*
- ISO: *Isoëto-Nanojuncetea*
- BID: *Bidentetea*

2.C.5. Salt Marsh

Eurasian Interior Wet Saline Marsh

Some inland saline marshes are placed in the European Coastal Salt Marsh division below.

- FEP: *Festuco-Puccinellietea*
- CRY: *Crypsietea aculeatae*
- KAL: *Kalidietea foliati*
- AEL: *Aeluropodetea littoralis*

European Coastal Salt Marsh

The separation of inland versus coastal salt marshes is not always made at the class level, as with the *Therosalicornietea*.

3.A.2. Warm Desert & Semi-Desert Scrub & Grassland

Mediterranean-Macaronesian Warm Semi-Desert Scrub & Grassland

- PEG: *Pegano harmalae-Salsoletea vermiculatae*
- KLE: *Kleinio neriifoliae-Euphorbietea canariensis*
- SUP: *Spartocytisetea supranubii*
  Remark: This class occupies the high altitudes on the Canary Islands above the cloud belt where Macaronesian Warm Temperate Forest & Scrub are found. Therefore, the climatic conditions are relatively cool.

3.B.1. Cool Semi-Desert Scrub & Grassland

Eurasian Cool Semi-Desert Scrub & Grassland

- LER: *Artemisietea lerchianae*

4.B.1. Temperate & Boreal Alpine Vegetation

European Alpine Dwarf-Shrub & Grassland

This division is quite distinct from the Oromediterranean alpine division described below, and placing these two together in one formation hides the close relationship of this division to the Arctic Tundra & Barrens Division in the Polar Tundra & Barrens formation (4.B.2) (see Discussion for more details).

- SES: *Elyno-Seslerietea*
- TRI: *Juncetea trifidi* p.p. [excl. TRI-01 *Juncetalia trifidi*]
  Remark: The concept adopted for this class in Mucina et al. (2016) does not fit into the current IVC formation system. Without prejudging a future revision, we exclude here the boreo-arctic order TRI-01 *Juncetalia trifidi* (see Formation 4.B.2.).
- IND: *Festucetea indigestae*
- PIL: *Saginetea piliferae*

Oromediterranean Alpine & Subalpine Grassland & Scrub

See comment above under European Alpine Dwarf-shrub & Grassland. This division largely contains cushion-tragacanthic alpine scrub.

- RUM: *Rumici-Astragaletea siculi*
- ANA: *Trifolio anatolici-Polygonetea arenastri*
- GEN: *Carici-Genistetea lobelii*
- DAP: *Daphno-Festucetea*
- CYP: *Diantho troodi-Teucrietea cyprii*

4.B.2. Polar Tundra & Barrens

[Temperate high alpine to arctic vegetation]

Arctic Tundra & Barrens

Some classes that extend into the temperate high alpine zone have close floristic relation to classes in the European Alpine Dwarf-shrub & Grassland division of the alpine formation 4.B.1. (see remarks under specific classes).

- KOB: *Carici rupestris-Kobresietea bellardii*
  Remark: Also occurs in the high alpine belt of cool temperate mountains.
- LOI: *Loiseleurio procumbentis-Vaccinietea* p.p. [LOI-03A *Loiseleurio-Arctostaphylion*]
  Remark: Delimitation between the *Loiseleurio-Vaccinietea* and *Juncetea trifidi* is controversial, and a broad-scale phytosociological revision would be needed to clarify the issue. Most of the class corresponds to the Boreal Grassland & Shrubland formation (2.B.3.).
- TRI: *Juncetea trifidi* p.p. [TRI-01 *Juncetalia trifidi*]
  Remark: The order TRI-01 *Juncetalia trifidi* includes arctic swards, but also extends into the alpine belt of Northern Europe (i.e., the boreal zone) and even includes "glacial relict" communities in the Hercynic Mountains of Central Europe.
- HER: *Salicetea herbaceae*
  Remark: Also widespread in the high alpine belt of cool temperate mountains.
- PAP: *Drabo corymbosae-Papaveretea dahliani*
- COC: *Saxifrago cernuae-Cochlearietea groenlandicae*
- SAX: *Saxifrago tricuspidatae-Calamagrostietea purpurascentis*
- ARC: *Matricario-Poetea arcticae*

5.A.3. Benthic Vascular Saltwater Vegetation

Temperate Atlantic Seagrass Aquatic Vegetation

- HAL: *Halodulo wrightii-Thalassietea testudinum*
- RUP: *Ruppietea maritimae*
- ZOS: *Zosteretea*

5.B.2. Temperate to Polar Freshwater Aquatic Vegetation

Temperate Eurasian Freshwater Aquatic Vegetation

This division concept might need further revision as the class *Lemnetea* is described in Mucina et al. (2016) as having a Holarctic distribution (though its one order has a temperate European distribution). The classes *Platyhypnidio-Fontinalietea antipyreticae* (listed in EVC2) and *Charetea intermediae* (listed in EVC3) should also be included here.

- LEM: *Lemnetea*
- POT: *Potamogetonetea*

6.B.1. Temperate & Boreal Cliff, Scree & Other Rock Vegetation

Macaronesian Cliff, Scree & Other Rock Vegetation

- AEO: *Aeonio-Greenovietea*
- VIO: *Violetea cheiranthifoliae*

Western Eurasian Cliff, Scree & Other Rock Vegetation

Various classes of epilithic bryophyte and lichen communities (listed in EVC2) should also be included here (see also Berg et al. 2020).

- ADI: *Adiantetea*
- POD: *Polypodietea*
- ASP: *Asplenietea trichomanis*
- CYM: *Cymbalario-Parietarietea diffusae*
- PHA: *Phagnalo saxatilis-Rumicetea indurati*
- DRY: *Drypidetea spinosae*
- THL: *Thlaspietea rotundifolii*
  Remark: This is a rather heterogenous class, spanning a gradient from thermophilous submediterranean to temperate nival and arctic communities. The latter would better fit into the Polar Tundra & Barrens formation (4.B.2.).
- LAM: *Lamio tomentosi-Chaerophylletea humilis*

7.B.4. Fallow Field & Weed Vegetation

Eurasian Fallow Field & Weed Vegetation [cultural]

- PAR: *Papaveretea rhoeadis*
- CHE: *Chenopodietea*
- DIG: *Digitario sanguinalis-Eragrostietea minoris*
- SIS: *Sisymbrietea*
- POL: *Polygono-Poetea annuae*

7.B.5. Herbaceous Wetland Crop

Eurasian Fallow Field & Weed Vegetation [cultural, wet]

- ORY: *Oryzetea sativae*

Discussion

Evaluation of class concepts

From a Braun-Blanquet approach perspective, it has been proposed (Pignatti et al. 1995; Willner 2006, 2020) to consider syntaxa as acceptable only if they have, on the one hand, a floristic basis (i.e., a sufficient set of diagnostic species), but on the other hand also an ecological basis (i.e., a measurable range of climatic and edaphic preferences with little or no overlap with the neighbouring community types) and an evolutionary significance (i.e., chorological and biogeographical information). For our purposes, we expand the "floristic basis" to include growth forms and structural attributes. Acceptable vegetation types should be clearly discriminated along environmental gradients.

Our approach is not unlike that of Pignatti et al. (1995) who evaluated European vegetation classes in terms of their status of class character species, ecological characterization, coherence of the geographical distribution of character species and common physiognomy-structure. However, our goal was to assess whether mismatches in placement of classes within formations relate to relative weaknesses in any of the mismatched class or formation concepts. When the fit is poor, the class definition might be too broad, or the formation definitions might be too narrow, or both.

EVC classes which seem to be too heterogenous to fit into the IVC formation system include the *Oleo cerasiformis-Rhamnetea crenulatae*, *Crataego-Prunetea*, *Vaccinio-Piceetea*, *Loiseleurio-Vaccinietea*, *Juncetea trifidi* and *Thlaspietea rotundifolii*. Delimitation of *Vaccinio-Piceetea*, *Loiseleurio-Vaccinietea* and *Juncetea trifidi* has been a matter of debate for many decades (e.g., Grabherr and Mucina 1993; Daniëls 1994; Dierßen 1996). The IVC perspective might help to solve these intricate issues.

Mesomorphic unfertilized subalpine grasslands (partly natural, e.g., in avalanche gullies, partly maintained by grazing) are currently included in the same classes as typical alpine tundra (*Juncetea trifidi*, *Elyno-Seslerietea*) due to some common species. However, this concept is not unchallenged (especially concerning the placement of subalpine *Nardus stricta* swards). From a physiognomic point of view, the subalpine grasslands would better fit in the Temperate Grassland & Shrubland formation (2.B.2).

More fundamentally, the European grassland classes (*Nardetea strictae*, *Molinio-Arrhenatheretea*, *Festuco-Brometea* etc.) span a much larger natural to anthropogenic gradient than in eastern North America, where all seeded pastures (of which the vast majority are of introduced European grasses) are placed in 7.B.2 Pasture & Hay Field Crop. These pastures may be grazed by cattle or used as hay meadows. In addition, in North America, urban and park lawns, sport fields, golf courses, and the like are included in 7.C.1. Lawn, Garden and Recreational Vegetation. In Europe, pastures and hay meadows are composed of native European species, and they are a product of long "co-evolution" between nature and human land use. Therefore, there is no sharp border between natural and anthropogenic grasslands, and all traditionally managed grasslands must be regarded as semi-natural. "Artificial" (or cultural) grasslands that mainly consist of sown plants exist as well. However, similar to plantations of non-native trees, they are not treated as communities in the Braun-Blanquet system and therefore have no corresponding EVC class.

Wet meadows are currently included in the class *Molinio-Arrhenatheretea*. However, several authors have considered wet meadows as classes in their own right (*Molinio-Juncetea acutiflori*, *Agrostietea stoloniferae*). The same is true for megaforbic fringes on wet sites (*Filipendulo ulmariae-Calystegietea*). The position of wet communities dominated by rather low-growing shrubs (e.g., *Salix repens*) should also be reconsidered. They are currently included in tall-shrub classes such as the *Franguletea*. As a consequence, Formation 2.C.4. Temperate to Polar Freshwater Marsh, Wet Meadow & Shrubland currently contains no classes that represent wet meadows, nor wet shrubland.

The class *Thlaspietea rotundifolii* comprises scree vegetation from the submediterranean and temperate colline belt up to the nival belt and arctic barrens, with the extremes having not a single species in common. A revision of the whole phytosociological class seems necessary.

Evaluation of formation concepts

There are cases of mismatches between phytosociological classes and IVC formations that might better be solved by emending the current formation concepts:

Tall shrubs/scrub and Forest & Woodland

We included tall shrub communities (dominated by shrubs > 2 m, cover of tall shrubs and trees > 50%) in the Forest & Woodland formation class because they are not separated from forests and woodlands at higher phytosociological levels. There are physiognomic, floristic, and ecological arguments supporting this approach: Some species can be either trees or tall shrubs; they often have very similar companion species in the herb layer; from the perspective of understorey herbs and animals, there is not much difference between a tree and a tall shrub. Another advantage is that the extremely heterogeneous Grassland & Shrubland formation class becomes physiognomically more uniform. On shallow soils, or near the treeline, tall shrub communities (as well as krummholz of *Fagus sylvatica* and *Pinus mugo*) may have only 1–2 m height, without corresponding floristic differences.

Boreal and temperate high montane

Eurasian boreal and temperate-montane *Picea* forests have always been included in the same class *Vaccinio-Piceetea*, and even in the same alliance (e.g., PIC-01A *Piceion excelsae* – European boreo-montane spruce forests and subalpine open pine woods on nutrient-poor podzolic soils; Mucina et al. 2016). The floristic core of temperate high montane–subalpine coniferous forests is very similar to boreal forests, although they are enriched by species with nemoral distribution. Basically, the temperate high montane–subalpine coniferous forest belt can be considered as extrazonal. In general, high montane–subalpine coniferous forests of the cool temperate zone are usually either dominated by the same species as in the boreal zone (e.g., *Picea abies* in Europe, *Abies lasiocarpa* in North America), or by very closely related species (e.g. *Pinus cembra* – *P. sibirica* in Eurasia, *Picea engelmannii* – *P. glauca* in North America). The understorey of these subalpine forests also shows strong affinities with the boreal forest. We therefore include both the boreal forest proper, as well as temperate high montane to subalpine forest and tall scrub in the same formation. Analogous considerations suggest that boreal and temperate high montane–subalpine grassland vegetation could be included within one formation.

Review of this decision with eastern Eurasian and North American colleagues is needed to confirm placement of these extrazonal types within this formation.

Boreal and temperate flooded and swamp forests

Separation of boreal and temperate flooded & swamp forests (formations 1.B.3. and 1.B.5.) is difficult as their floristic composition reflects the gradient from oligotrophic to eutrophic rather than macroclimate. Therefore, phytosociological classes are present in both zones, and it may be best to combine the two formations into a "Temperate & Boreal Flooded & Swamp Forest". This would also be consistent with how other wetland formations are defined (e.g., shrub and herb wetlands typically range from Temperate to Polar).

Polar tundra and alpine grasslands

The delimitation of Temperate & Boreal Alpine Vegetation (formation 4.B.1.) and Polar Tundra & Barrens (4.B.2.) may need revision. Arctic and alpine tundra and snowbed vegetation share the same floristic core of arctic-alpine species, though the temperate alpine vegetation is enriched by species that are not present in the arctic. Therefore, they are not separated at the level of phytosociological classes (*Carici-Kobresietea*, *Juncetea trifidi*, *Loiseleurio-Vaccinietea*, *Salicetea herbaceae*). Boreal alpine and arctic vegetation are even placed in the same alliances. In contrast, the oromediterranean thorn cushion scrub, typical for the alpine belt of warm-temperate regions with dry summers (from the Mediterranean in the west to Central Asia in the east), is physiognomically and ecologically very different from the arctic and boreo-temperate alpine tundra. As with the extrazonal classes of the boreal forest, a global review of the placement of boreo-temperate alpine vegetation is needed.

Floristically heterogeneous formations

Finally, some formations might appear quite lumpy, comprising phytosociological classes that, at first glance, do not have much in common. Formation 1.B.2. Cool Temperate Forest & Woodland includes deciduous and coniferous forests as well as tall scrub. However, separation of these three structural types is often difficult, even at the level of phytosociological classes, so placement within a single formation seems appropriate. The Grassland & Shrubland Formations 2.B.2., 2.C.4. and 2.C.5. include pioneer communities rich in annuals (e.g., *Helianthemetea guttati*, *Sedo-Scleranthetea*, *Isoëto-Nanojuncetea*, *Saginetea maritimae*), which often grow in gaps within perennial scrub and grassland communities (see also Pignatti et al. 1995). It might be argued that these communities do not fit into the current formation scheme, as they correspond to communities usually sampled with plots of 1–4 m² (Chytrý and Otýpková 2003). This kind of small-scale communities have not been recognized in the EcoVeg approach, and their placement in the formation system might need revision (see also next section below). However, they can cover larger areas in strongly disturbed habitats. Perennial forb vegetation of ruderal habitats and forest clearings (*Artemisietea vulgaris*, *Epilobietea angustifolii*) is often grouped with weed vegetation (also in Mucina et al. 2016), but from a physiognomic point of view, the vegetation better fits in the Temperate Grassland & Shrubland formation. Importantly, these two classes do not only occur in anthropogenic habitats but also on sites naturally disturbed by animals or storms.

Annual weed vegetation

The formation assignment of annual weed vegetation is problematic. By definition, these communities only comprise spontaneously growing plant species; thus, in Europe, they are not considered cultural ("artificial") vegetation. However, their habitat is strongly determined by anthropogenic activities, and crops may be present with high cover. Therefore, they are here assigned to the formation class Agricultural & Developed Vegetation, which also includes cultural vegetation not considered in the Braun-Blanquet system. Apart from weed communities of rice fields, all weed vegetation classes have been assigned to formation 7.B.4. Fallow Field & Weed Vegetation. Indeed, weed vegetation is not directly dependent on the cultivated crops, and often the communities are best developed on young fallow fields or along the margin of crop fields.

Scale of plot sampling and formation placement

Occasionally, physiognomic placement of classes is difficult when the sampling of the vegetation is conducted at a fine grain. In Europe, plot sizes for all non-forested vegetation are typically less than 100 m². Plots of this size may be physiognomically uniform, even when the physiognomic pattern at a larger scale is more complex. For example, we placed *Cytisetea scopario-striati*, *Crataego-Prunetea*, *Salicetea arenariae*, *Lonicero-Rubetea plicati*, and *Franguletea* in the Forest & Woodland formation class. The concept of these tall-scrub units refers only to shrub-dominated patches and excludes grassland and low-scrub patches in between (which may belong to the *Cisto-Lavanduletea*, *Festuco-Brometea*, *Nardetea strictae* etc.). Tall shrubs only rarely form up to one hectare of pure tall-scrub; more often, patches are intermingled with grasslands or form linear structures along forest edges or free-standing hedges, with no grassland context (Figure 1). The ecological reasoning behind these tall-scrub classes is that they represent a successional stage between grassland and woodland or are squeezed in between them along an environmental gradient. Biogeographically, they are strongly linked to the temperate forest climate. The tall shrubs are considered aliens in the grassland, and they outcompete the herb layer in the absence of disturbances, ultimately transforming the grassland into a woodland. In dense forests, they are outcompeted themselves, but in light oak woodland they usually find enough space to survive. Still, if their shrub structure is partly based on natural disturbance processes that maintain the larger scale shrubland-grassland mosaic, then an argument could be made that physiognomically and ecologically, they belong in the Shrub and Herb Vegetation class.

Figure 1. Open *Quercetea pubescentis* woodland in eastern Austria with high abundance of thermophilous shrubs (**A**) and various stands of seral tall-scrub of the *Crataego-Prunetea* (**B–D**). Note that the grasslands adjacent to the tall-scrub is not included in the *Crataego-Prunetea* but belongs to other classes such as the *Festuco-Brometea*, *Trifolio-Geranietea*, *Molinio-Arrhenatheretea* etc. (all photos by W. Willner).

Plot sampling traditions in the U.S. rarely use plot samples less than 100 m^2; more often the plot is between 100 and 1,000 m^2 (Peet and Roberts 2013). In contrast, 16 m^2 have been suggested as standard plot size for grasslands within the framework of the Braun-Blanquet approach (Chytrý and Otýpková 2003). Thus, in the first case the physiognomy of a plot may be described as a shrub grassland, while in the second case it may be considered a mosaic of grassland and tall-scrub.

Small-scale pioneer communities such as the *Sedo-Scleranthetea*, *Isoëto-Nanojuncetea* or *Saginetea maritimae* are usually sampled at even smaller scales. The same is true for vegetation dominated by bryophytes and lichens, most of which is included in EVC2 in Mucina et al. (2016). Chytrý and Otýpková (2003) recommended 4 m^2 for small-scaled vegetation, and a recent proposal suggested 1 m^2 as the minimum plot size for a phytocoenosis (Berg et al. 2020). Communities sampled with vastly different plot sizes cannot be directly compared, and in fact may represent different scales in the vegetation mosaic. Thus, merging these classes with grasslands is somewhat methodologically problematic. Accepting that various plot sample sizes will occur within formations, division subgroupings might be a pragmatic solution.

A common definition for the macrogroup/class level?

Perhaps surprisingly, there is no widely agreed upon definition for the vegetation class in the Braun-Blanquet approach (Pignatti et al. 1995; Mucina et al. 2016; Loidi 2020). While the rank was introduced as early as 1926 (Koch 1926), overviews of classes were not published before the 1940s (Braun-Blanquet and Tüxen 1943; Kilka and Hadač 1944), one or two decades after the description of most alliances and orders. Only then were these units organized into classes. The classes were developed in a bottom-up approach purely based on floristic similarity, independent from (and frequently even in contradiction to) earlier formation systems. From the 1960s onwards, physiognomic considerations started to slowly seep into the Braun-Blanquet approach, leading to a gradual splitting of physiognomically heterogeneous classes – a process which is still not finished (see Bonari et al. 2021).

Within the EcoVeg approach, the macrogroup level is constrained by the formation level and organized by the division level, as well as being informed by lower level units. Thus, it is useful to ask how similar the macrogroup concept is to the current BB class concept.

The Macrogroup (L5) is defined by moderate sets of diagnostic plant species and diagnostic growth forms that reflect biogeographic differences in composition and sub-continental to regional differences in mesoclimate, geology, substrates, hydrology, and disturbance regimes (Faber-Langendoen et al. 2014). A macrogroup type typically contains a moderately large set (dozens) of strongly diagnostic species that share a broadly similar physiognomy and ecology in response to continental, sub-continental, or regional differences in ecological factors. Thus, the macrogroup expresses the floristic, growth form and regional ecological factors that separate vegetation types within a division.

Many EVC classes have distribution ranges covering the whole of western Eurasia, while biogeographical differences in species composition are reflected at the level of orders and alliances (Mucina et al. 2016). This seems to contradict the definition of the macrogroup given above and also the current practice in North America, where there are often two or more geographically vicariant macrogroups within a division. For instance, within the Eastern North American Forest & Woodland division there are four macrogroups of mesic forests: Appalachian-Interior-Northeastern Mesic Forest, Central Midwest Mesic Forest, Laurentian Mesic Forest, and Acadian-Northern Appalachian Mesic Forest (Faber-Langendoen et al. 2018). There could be several reasons for this seeming mismatch. One is the historic tradition in northeastern North America of distinguishing these classes based on strongly divergent tree composition (e.g., Braun 1950). This may reflect a higher biogeographical diversity in this region as compared to Europe. In this case, different ranges of macrogroups and EVC classes would reflect objective differences in the vegetation of both continents. On the other hand, the differences could also be the result of divergent methodological approaches: The class is the highest official unit in the Braun-Blanquet system, and often it is the only rank linking vegetation types in different parts of Europe together. Proposing a new class is a bold step and not easily accepted by the phytosociological community. Moreover, most dominant and constant species of associations have wide distribution ranges, and these species can only be considered as character species of vegetation units if these units have equally wide distribution ranges. Conversely (see also section below), because the EcoVeg approach has a division level, these intra-continental patterns are readily recognized, and testing of their diagnostic strength can be reviewed through large-scale plot-based analyses. Intercontinental comparisons are needed to further elucidate this issue. However, we believe that, in the long run, a common macrogroup/class concept would be beneficial for the global evaluation of vegetation diversity.

Merits of the division concept for organizing Braun-Blanquet classes

In the context of European vegetation (as covered by EVC), the strength of the IVC approach is largely that it adds a set of physiognomic and ecological criteria that effectively organizes the classes, which are already being increasingly informed by physiognomy (most recently see Bonari et al. 2021). That is, the formation concepts are relatively natural extensions of concepts embedded in the classes. Thus, as with Mucina (1997) and Rodwell et al. (2002), we advance the use of the formation, and its extension at the division level, as an organizing set of levels for EVC classes, using an international-based set of formations.

Given the geographical scope of EVC (i.e., the western part of Eurasia), it is perhaps not surprising that most European vegetation classes fall within one or a few divisions within a formation. The division level accounts for large biogeographically distinct expressions of formations, such that e.g., Mediterranean Basin forests are placed in the context of all Mediterranean type vegetation around the globe, Western Eurasian temperate forests are separated from those in East Asia, North America, and other parts of the globe, and Eurasian boreal forests from their North American counterpart. Most importantly, by organizing the classes within such a well-researched part of the globe, a hierarchical structure is provided to researchers in many other countries in how to seek consensus on class concepts based on the well-established traditions in Europe. In addition, groupings of classes ("division subtype") may be an important addition to the division level concept when many classes occur within a formation (e.g., see the division grouping within the Western Eurasian Cool Temperate Forest).

Conclusions

With the completion of division level concepts for Europe, there are now division concepts for Western Eurasia, all of the Americas (Faber-Langendoen et al. 2018), for Africa (Sayre et al. 2013), and for all grasslands and shrublands (Dixon et al. 2014). Macrogroup and/or BB class concepts are also largely complete for these areas, and Division and macrogroup concepts have also been piloted in Australia (Muldavin et al. 2021). Formation level concepts as developed for the IVC (Faber-Langendoen et al. 2016) already reflect a long tradition of well-established concepts, but extensions of ecological criteria to include ecological functions may enrich these concepts (Keith et al. 2020). It is now possible to consider compiling a compendium of BB class concepts, IVC macrogroup concepts, and closely related concepts, using division and formation level units. These compendiums could build on existing publicly available webtools in Europe (http://euroveg.org/) and in the Americas (https://explorer.natureserve.org/). Such an effort would more firmly establish a consistent set of guiding principles for the use of physiognomy, floristics, biogeography, and ecology in the construction of hierarchically consistent approaches. It would also further the aim of guiding IUCN Red Lists of Ecosystems for terrestrial and wetland ecosystems (e.g., Ferrer-Paris et al. 2018), as a complement to the recent global framework of Keith et al. (2020), which does not provide the needed lower-level units of that hierarchy.

The goal of comparing and compiling units across various classifications is not to develop a single authoritative system, but, in the mindset of Sterner et al. (2020), to

collaborate based on the Coordinative Consensus Principle (CCP). Using that principle, the ground of consensus is communicative expediency, rather than metaphysical truth or epistemic agreement about a single classification hierarchy. The philosophical approach to coordinating the existing "classification dissent" (taxonomic pluralism) among vegetation ecologists is to bring the full spectrum of global vegetation in view using a few global backbone classifications that assist in the compilation, while still firmly anchoring all relationships of types with subnational or national partner classifications (e.g., by using established relationship methods, such as the RCC-5 method of Sterner et al. 2020). In this way the goal is to build reliable relationships between global and local classifications and to facilitate information exchanges, whether about types, plot data, or conservation information.

Author contributions

W.W. had the idea for this paper, and both authors equally contributed to the writing.

References

Berg C, Ewald J, Hobohm C, Dengler J (2020) The whole and its parts: why and how to disentangle plant communities and synusiae in vegetation classification. Applied Vegetation Science 23: 127–135. https://doi.org/10.1111/avsc.12461

Bonari G, Fernández-González F, Çoban S, Monteiro-Henriques T, Bergmeier E, Didukh YP, Xystrakis F, Angiolini C, Chytrý K, …, Chytrý M (2021) Classification of the Mediterranean lowland to submontane pine forest vegetation. Applied Vegetation Science 24: e12544. https://doi.org/10.1111/avsc.12544

Braun EL (1950) The deciduous forests of Eastern North America. Blakiston Co, Philadelphia, PA, US, 596 pp.

Braun-Blanquet J (1921) Prinzipien einer Systematik der Pflanzengesellschaften auf floristischer Grundlage. Jahrbuch der St. Gallener Naturwissenschaftlichen Gesellschaft 57: 305–351.

Braun-Blanquet J (1964) Pflanzensoziologie. Grundzüge der Vegetationskunde. 3rd edn. Springer, Wien, AT. https://doi.org/10.1007/978-3-7091-8110-2

Braun-Blanquet J, Tüxen R (1943) Übersicht der höheren Vegetationseinheiten Mitteleuropas (unter Ausschluss der Hochgebirge). Communication de la Station Internationale de Géobotanique Méditerranéenne et Alpine 84: 1–11.

Cervellini M, Zannini P, Di Musciano M, Fattorini S, Jiménez-Alfaro B, Rocchini D, Field R, Vetaas OR, Irl SDH, …, Chiarucci A (2020) A grid-based map for the Biogeographical Regions of Europe. Biodiversity Data Journal 8: e53720. https://doi.org/10.3897/BDJ.8.e53720

Chytrý M, Otýpková Z (2003) Plot sizes used for phytosociological sampling of European vegetation. Journal of Vegetation Science 14: 563–570. https://doi.org/10.1111/j.1654-1103.2003.tb02183.x

Dallman PR (1998) Plant life in the World's Mediterranean climates: California, Chile, South Africa, Australia, and the Mediterranean Basin. California Native Plant Society, University of California Press, Berkeley, CA, US.

Daniëls FJA (1994) Vegetation classification in Greenland. Journal of Vegetation Science 5: 781–790. https://doi.org/10.2307/3236193

Dengler J, Chytrý M, Ewald J (2008) Phytosociology. In: Jorgensen SE, Fath BD (Eds) Encyclopedia of Ecology, vol. 4, General Ecology. Elsevier, Oxford, UK, 2767–2779. https://doi.org/10.1016/B978-008045405-4.00533-4

Dierßen K (1996) Vegetation Nordeuropas. Ulmer, Stuttgart, DE, 838 pp.

Dixon A, Faber-Langendoen D, Josse C, Morrison J, Loucks CJ (2014) Distribution mapping of world grassland types. Journal of Biogeography 41: 2003–2019. https://doi.org/10.1111/jbi.12381

Ewald J (2003) A critique of phytosociology. Journal of Vegetation Science 14: 291–296. https://doi.org/10.1111/j.1654-1103.2003.tb02154.x

Faber-Langendoen D, Keeler-Wolf T, Meidinger D, Tart D, Hoagland B, Josse C, Navarro G, Ponomarenko S, Saucier J-P, …, Comer P (2014) EcoVeg: a new approach to vegetation description and classification. Ecological Monographs 84: 533–561. https://doi.org/10.1890/13-2334.1

Faber-Langendoen D, Keeler-Wolf T, Meidinger D, Josse C, Weakley A, Tart D, Navarro G, Hoagland B, Ponomarenko S, …, Helmer E (2016) Classification and description of world formation types. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station [General Technical Report RMRS-GTR-346], Fort Collins, CO, US, 222 pp. https://doi.org/10.2737/RMRS-GTR-346

Faber-Langendoen D, Baldwin K, Keeler-Wolf T, Meidinger D, Muldavin E, Peet RK, Josse C (2018) The EcoVeg Approach in the Americas: U.S., Canadian, and International Vegetation Classifications. Phytocoenologia 48: 215–237. https://doi.org/10.1127/phyto/2017/0165

Faber-Langendoen D, Navarro G, Willner W, Keith DA, Liu C, Guo K, Meidinger D (2020) Perspectives on terrestrial biomes: The International Vegetation Classification. In: Goldstein MI, DellaSala DA (Eds) Encyclopedia of the World's Biomes, vol. 1. Elsevier, Oxford, UK, 1–15. https://doi.org/10.1016/B978-0-12-409548-9.12417-0

Ferrer-Paris JR, Zager I, Keith DA, Oliveira-Miranda MA, Rodríguez JP, Josse C, González-Gil M, Miller RM, Zambrana-Torrelio C, Barrow E (2018) An ecosystem risk assessment of temperate and tropical forests of the Americas with an outlook on future conservation strategies. Conservation Letters 12: 1–10. https://doi.org/10.1111/conl.12623

Grabherr G, Mucina L [Eds] (1993) Die Pflanzengesellschaften Österreichs. Teil II. Natürliche waldfreie Vegetation. Gustav Fischer, Jena, DE, 523 pp.

Guarino R, Willner W, Pignatti S, Attorre F, Loidi J (2018) Spatio-temporal variations in the application of the Braun-Blanquet approach in Europe. Phytocoenologia 48: 239–250. https://doi.org/10.1127/phyto/2017/0181

Guo K, Liu C-C, Xie Z-Q, Li FY, Franklin SB, Lu Z-J, Ma K-P (2018) China vegetation classification: concept, approach and applications. Phytocoenologia 48: 113–120. https://doi.org/10.1127/phyto/2017/0166

Jakucs P (1967) Gedanken zur höheren Systematik der europäischen Laubwälder. Contribuţii Botanici Cluj 1967: 159–166.

Keith DA, Ferrer-Paris JR, Nicholson E, Kingsford RT [Eds] (2020) The IUCN Global Ecosystem Typology 2.0: Descriptive profiles for biomes and ecosystem functional groups. IUCN, Gland, CH. https://doi.org/10.2305/IUCN.CH.2020.13.en

Klika J, Hadač E (1944) Rostlinná společenstva střední Evropy [Plant communities of Central Europe]. Příroda 36: 249–259, 281–295.

Koch W (1926) Die Vegetationseinheiten der Linthebene unter Berücksichtigung der Verhältnisse in der Nordostschweiz. Jahrbuch der St. Gallischen Naturwissenschaftlichen Gesellschaft 61 [1925]: 1–146.

Loidi J (2020) The concept of vegetation class and order in phytosociological syntaxonomy. Vegetation Classification and Survey 1: 163–167. https://doi.org/10.3897/VCS/2020/59977

Luebert F, Pliscoff P (2006) Sinopsis bioclimática y vegetacional de Chile. 1st edn. Editorial Universitaria, Santiago, CL, 316 pp.

MacKenzie WH, Meidinger DV (2018) The biogeoclimatic ecosystem classification approach: an ecological framework for vegetation classification. Phytocoenologia 48: 203–214. https://doi.org/10.1127/phyto/2017/0160

Moncrieff GR, Bond JW, Higgins SI (2016) Revising the biome concept for understanding and predicting global change impacts. Journal of Biogeography 43: 863–873. https://doi.org/10.1111/jbi.12701

Mucina L (1997) Conspectus of classes of European vegetation. Folia Geobotanica 32: 117–172. https://doi.org/10.1007/BF02803738

Mucina L (2018) Biome: evolution of a crucial ecological and biogeographical concept. New Phytologist 222: 97–114. https://doi.org/10.1111/nph.15609

Mucina L, Bültmann H, Dierßen K, Theurillat J-P, Raus T, Čarni A, Šumberová K, Willner W, Dengler J, …, Tichý L (2016) Vegetation of Europe: hierarchical floristic classification system of vascular plant, bryophyte, lichen and algal communities. Applied Vegetation Science 19(Suppl. 1): 3–264. https://doi.org/10.1111/avsc.12257

Mueller-Dombois D, Ellenberg H (1974) Aims and methods of vegetation ecology. John Wiley & Sons, New York, US.

Muldavin EH, Addicott E, Hunter JT, Lewis D, Faber-Langendoen D (2021) Australian Vegetation Classification and the International Vegetation Classification Framework: an overview with case Studies. Australian Journal of Botany 69: 339–356. https://doi.org/10.1071/BT20076

Passarge H (1966) Die Formationen als höchste Einheiten der soziologischen Vegetationssystematik. Feddes Repertorium 73: 226–235. https://doi.org/10.1002/fedr.19660730308

Peet RK, Roberts DW (2013) Classification of natural and semi-natural vegetation. In: van der Maarel E, Franklin J (Eds) Vegetation ecology. 2nd edn. Wiley, Chichester, UK, 28–70. https://doi.org/10.1002/9781118452592.ch2

Pignatti S, Oberdorfer E, Schaminée JHJ, Westhoff V (1995) On the concept of vegetation class in phytosociology. Journal of Vegetation Science 6: 143–152. https://doi.org/10.2307/3236265

Pignatti E, Pignatti S, Ladd PG (2002) Comparison of ecosystems in the Mediterranean Basin and Western Australia. Plant Ecology 163: 177–186. https://doi.org/10.1023/A:1020968010349

Rodwell JS, Schamineé JHJ, Mucina L, Pignatti S, Dring J, Moss D (2002) The diversity of European vegetation – An overview of phytosociological alliances and their relationships to EUNIS habitats. National Reference Centre for Agriculture, Nature and Fisheries [Report no. EC-LNV 2002(054)], Wageningen, NL, 167 pp.

Sayre R, Comer P, Hak J, Josse C, Bow J, Warner H, Larwanou M, Kelbessa E, Bekele T, …, Waruingi L (2013) A new map of standardized terrestrial ecosystems of Africa. Association of American Geographers, Washington DC, US.

Sterner B, Witteveen J, Franz N (2020) Coordinating dissent as an alternative to consensus classification: insights from systematics for bio-ontologies. History and Philosophy of the Life Sciences 42: 8. https://doi.org/10.1007/s40656-020-0300-z

Theurillat J-P, Aeschimann D, Küpfer P, Spichiger R (1995) The higher vegetation units of the Alps. Colloques Phytosociologiques 23: 189–239.

Westhoff V, van der Maarel E (1973) The Braun-Blanquet approach. In: Whittaker RH (Ed.) Ordination and classification of communities [Handbook of vegetation science 5]. Junk, The Hague, NL, 617–726. https://doi.org/10.1007/978-94-010-2701-4_20

Whittaker RH (1975) Communities and ecosystems. 2nd edn. MacMillan, New York, US.

Willner W (2006) The association concept revisited. Phytocoenologia 36: 67–76. https://doi.org/10.1127/0340-269X/2006/0036-0067

Willner W (2020) What is an alliance? Vegetation Classification and Survey 1: 139–144. https://doi.org/10.3897/VCS/2020/56372

Appendix 1

List of IVC Formations (from Faber-Langendoen et al. 2016), with draft Divisions and EVC Classes (the latter from Mucina et al. 2016). Links to the descriptions of all IVC formations are also provided.

IVC Class	IVC Subclass	IVC Formation	Draft Division	EVC Class	IVC link on NatureServe Explorer
1. Forest & Woodland					https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.860217
	1.B. Temperate & Boreal Forest & Woodland				https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.860227
		1.B.1. Warm Temperate Forest & Woodland			https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.860255
			Macaronesian Warm Temperate Forest & Tall Scrub		
				Oleo cerasiformis-Rhamnetea crenulatae p.p.	
				Pruno lusitanicae-Lauretea azoricae	
				Lauro azoricae-Juniperetea brevifoliae	
				Cytiso-Pinetea canariensis	
			Mediterranean Basin Warm Temperate Sclerophyllous Forest & Tall Scrub		
				Quercetea ilicis	
				Cytisetea scopario-striati	
		1.B.2. Cool Temperate Forest & Woodland			https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.860241
			Western Eurasian Cool Temperate Forest & Tall Scrub 1 (zonal)		
				Carpino-Fagetea sylvaticae	
				Quercetea pubescentis	
				Quercetea robori-petraeae	
			Western Eurasian Cool Temperate Forest & Tall Scrub 2 (seral)		
				Crataego-Prunetea p.p.max.	

IVC Class	IVC Subclass	IVC Formation	Draft Division	EVC Class	IVC link on NatureServe Explorer
				Salicetea arenariae p.p.min.	
				Lonicero-Rubetea plicati	
				Robinietea	
			Western Eurasian Cool Temperate Forest & Tall Scrub 3 (azonal dry pine forest)		
				Erico-Pinetea	
				Pyrolo-Pinetea sylvestris	
				Junipero-Pinetea sylvestris	
			Southern Siberian Cool Temperate Forest		
				Asaro europaei-Abietetea sibiricae	
				Brachypodio pinnati-Betuletea pendulae	
		1.B.3. Temperate Flooded & Swamp Forest			https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.860261
			Western Eurasian Rich Flooded & Swamp Forest & Tall Scrub		
				Alno glutinosae-Populetea albae	
				Salicetea purpureae	
				Alnetea glutinosae	
				Franguletea	
			Eurasian Arid Flooded Forest & Tall Scrub		
				Nerio-Tamaricetea	
				Tamaricetea arceuthoidis	
		1.B.4. Boreal Forest & Woodland			https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.860236
			Eurasian Boreal & Temperate High Montane Forest & Tall Scrub		
				Vaccinio-Piceetea p.p.max.	
				Roso pendulinae-Pinetea mugo	
				Betulo carpaticae-Alnetea viridis	
		1.B.5. Boreal Flooded & Swamp Forest			https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.860237
			Eurasian Boreal Acidic Flooded & Swamp Forest & Tall Scrub		
				Vaccinio uliginosi-Pinetea [*Vaccinio-Piceetea* p.p.min.]	
2. Shrub & Herb Vegetation					https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.860211
	2.B. Temperate & Boreal Grassland & Shrubland				https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.860233
		2.B.1. Mediterranean Scrub & Grassland			https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.860273
			Mediterranean Basin Scrub & Grassland		
				Ononido-Rosmarinetea	
				Cisto-Lavanduletea stoechadis	
				Lygeo sparti-Stipetea tenacissimae	
				Stipo giganteae-Agrostietea castellanae	
				Poetea bulbosae	
				Helianthemetea guttati	
				Stipo-Trachynietea distachyae	
			Macaronesian Scrub & Grassland		
				Oleo cerasiformis-Rhamnetea crenulatae p.p.	
		2.B.2. Temperate Grassland & Shrubland			https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.860245
			Azorean Warm Temperate Grassland & Heath		
				Tolpido azoricae-Holcetea rigidi	
			European Temperate Grassland & Heath 1 (natural & semi-natural)		
				Amygdaletea nanae [*Crataego-Prunetea* p.p.min]	
				Calluno-Ulicetea	
				Nardetea strictae	
				Festuco-Brometea	
				Trifolio-Geranietea sanguinei	
				Festuco hystricis-Ononidetea striatae	
				Koelerio-Corynephoretea canescentis	
				Sedo-Scleranthetea	
			European Temperate Grassland & Heath 2 (ruderal & strongly anthropogenic)		
				Molinio-Arrhenatheretea	
				Artemisietea vulgaris	
				Epilobietea angustifolii	
		2.B.3. Boreal Grassland & Shrubland			https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.860266
			European Boreal & Temperate High Montane Scrub & Herb Vegetation		
				Loiseleurio procumbentis-Vaccinietea p.p.	
				Rhododendro hirsuti-Ericetea carneae	
				Mulgedio-Aconitetea	
		2.B.4. Temperate to Polar Scrub & Herb Coastal Vegetation			https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.860238
			Euro-Atlantic Coastal Scrub & Herb Vegetation		
				Salicetea arenariae p.p.max	
				Ammophiletea	
				Helichryso-Crucianelletea maritimae	
				Crithmo-Staticetea	
				Cakiletea maritimae	
			Macaronesian Coastal Scrub & Herb Vegetation		
				Polycarpaeo niveae-Traganetea moquini	

IVC Class	IVC Subclass	IVC Formation	Draft Division	EVC Class	IVC link on NatureServe Explorer
2.C. Shrub & Herb Wetland					https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.926082
	2.C.2. Temperate to Polar Bog & Fen				https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.860253
			Eurasian Bog & Fen		
				Oxycocco-Sphagnetea	
				Scheuchzerio palustris-Caricetea fuscae	
	2.C.4. Temperate to Polar Freshwater Marsh, Wet Meadow & Shrubland				https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.860268
			Eurasian Freshwater Marsh, Wet Meadow & Shrubland		
				Phragmito-Magnocaricetea	
				Montio-Cardaminetea	
				Littorelletea uniflorae	
				Isoëto-Nanojuncetea	
				Bidentetea	
	2.C.5. Salt Marsh				https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.860269
			Eurasian Interior Wet Saline Marsh		
				Festuco-Puccinellietea	
				Crypsietea aculeatae	
				Kalidietea foliati	
				Aeluropodetea littoralis	
			European Coastal Salt Marsh		
				Juncetea maritimi	
				Salicornietea fruticosae	
				Spartinetea maritimae	
				Therosalicornietea	
				Saginetea maritimae	
3. Desert & Semi-Desert					https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.860216
	3.A. Warm Desert & Semi-Desert Woodland, Scrub & Grassland				https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.860224
		3.A.2. Warm Desert & Semi-Desert Scrub & Grassland			https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.860252
			Mediterranean-Macaronesian Warm Semi-Desert Scrub & Grassland		
				Pegano harmalae-Salsoletea vermiculatae	
				Kleinio neriifoliae-Euphorbietea canariensis	
				Spartocytisetea supranubii	
	3.B. Cool Semi-Desert Scrub & Grassland				https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.860228
		3.B.1. Cool Semi-Desert Scrub & Grassland			https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.860250
			Eurasian Cool Semi-Desert Scrub & Grassland		
				Artemisietea lerchianae	
4. Polar & High Montane Scrub, Grassland & Barrens					https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.860213
	4.B. Temperate to Polar Alpine & Tundra Vegetation				https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.860229
		4.B.1. Temperate & Boreal Alpine Vegetation			https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.860272
			European Alpine Dwarf-shrub & Grassland		
				Elyno-Seslerietea	
				Juncetea trifidi p.p.	
				Festucetea indigestae	
				Saginetea piliferae	
			Oromediterranean Alpine & Subalpine Grassland & Scrub		
				Rumici-Astragaletea siculi	
				Trifolio anatolici-Polygonetea arenastri	
				Carici-Genistetea lobelii	
				Daphno-Festucetea	
				Diantho troodi-Teucrietea cyprii	
		4.B.2. Polar Tundra & Barrens			https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.860248
			Arctic Tundra & Barrens		
				Carici rupestris-Kobresietea bellardii	
				Loiseleurio procumbentis-Vaccinietea p.p.	
				Juncetea trifidi p.p.	
				Salicetea herbaceae	
				Drabo corymbosae-Papaveretea dahliani	
				Saxifrago cernuae-Cochlearietea groenlandicae	
				Saxifrago tricuspidatae-Calamagrostietea purpurascentis	
				Matricario-Poetea arcticae	
5. Aquatic Vegetation					https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.860214
	5.A. Saltwater Aquatic Vegetation				https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.860226
		5.A.3. Benthic Vascular Saltwater Vegetation			https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.877228
			Temperate Atlantic Seagrass Aquatic Vegetation		
				Halodulo wrightii-Thalassietea testudinum	
				Ruppietea maritimae	
				Zosteretea	
	5.B. Freshwater Aquatic Vegetation				https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.860222
		5.B.2. Temperate to Polar Freshwater Aquatic Vegetation			https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.877233
			Temperate Eurasian Freshwater Aquatic Vegetation		
				Lemnetea	
				Potamogetonetea	

IVC Class	IVC Subclass	IVC Formation	Draft Division	EVC Class	IVC link on NatureServe Explorer
6. Open Rock Vegetation					https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.860218
	6.B. Temperate & Boreal Open Rock Vegetation				https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.860230
		6.B.1. Temperate & Boreal Cliff, Scree & Other Rock Vegetation			https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.860263
			Macaronesian Cliff, Scree & Other Rock Vegetation		
				Aeonio-Greenovietea	
				Violetea cheiranthifoliae	
			Western Eurasian Cliff, Scree & Other Rock Vegetation		
				Adiantetea	
				Polypodietea	
				Asplenietea trichomanis	
				Cymbalario-Parietarietea diffusae	
				Phagnalo saxatilis-Rumicetea indurati	
				Drypidetea spinosae	
				Thlaspietea rotundifolii	
				Lamio tomentosi-Chaerophylletea humilis	
7. Agricultural & Developed Vegetation					https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.860215
	7.B. Herbaceous Agricultural Vegetation				https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.867665
		7.B.4. Fallow Field & Weed Vegetation			https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.867668
			Eurasian Fallow Field & Weed Vegetation [cultural]		
				Papaveretea rhoeadis	
				Chenopodietea	
				Digitario sanguinalis-Eragrostietea minoris	
				Sisymbrietea	
				Polygono-Poetea annuae	
		7.B.5. Herbaceous Wetland Crop			https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.877250
			Eurasian Fallow Field & Weed Vegetation [cultural, wet]		
				Oryzetea sativae	

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Supplementary material

Supplementary material 1
Class fit to IVC formations.
Link: https://doi.org/10.3897/VCS/2021/71299.suppl1